Appendix I: Protocol Development Summaries.

1. Invasive, Non-Native Plants

Protocol
Invasive Plants, Adaptive Sampling Early Detection Protocol for the Klamath Network.

Parks Where Protocol will be Implemented
All: Crater Lake, Lassen, Lava Beds, Oregon Caves, Redwood, and Whiskeytown.

Justification/Issues being Addressed
Non-native invasive species have been directly linked to a number of impacts that are in direct conflict with National Park Service management goals, including: the replacement of native vegetation (Tilman 1999), the loss of rare species (King 1985), changes in ecosystem structure, alteration of nutrient cycles and soil chemistry (Ehrenfeld 2003), shifts in community productivity (Vitousek 1990), reduced agricultural productivity, and changes in water availability (D'Antonio and Mahall 1991). The damage caused by non-native species to natural resources can be devastating and our understanding of the consequences is incomplete. Non-native species are second only to habitat loss as a threat to wildland biodiversity (Wilcove et al. 1998). Consequently, the dynamic relationships among plants, animals, soil, and water established over long periods of time are at risk of being degraded in a relatively brief period.

Given the ecological impacts of non-native species, it is understandable that they ranked as the top vital sign for monitoring within the Klamath Network. Although a variety of non-natives are of concern, invasive plants are the most pervasive problem. Vulnerability to invasive plants differs among parks in the Network, and the optimal monitoring to address each park's management needs likewise differs. For example, Redwood and Whiskeytown are especially vulnerable to invasion due to the low elevations in much of the parks, high levels of visitor use, and, at Whiskeytown, mechanical and soil disturbances associated with fuelbreaks and other vegetation manipulations. The shrub-steppe ecosystems at Lava Beds are very prone to invasion by cheatgrass. Even Crater Lake and Lassen, which currently have few non-native plants due to their higher elevations, could become vulnerable to future invasion. Despite the different circumstances in parks, early detection of incipient populations and new species is the best general approach for monitoring this vital sign across the Network for most management goals.

Prevention of plant invasions is the most effective, economical, and ecologically sound approach to managing invasive species (USDA 2001). When preventive measures are not successful, approaches dependent upon early detection of new species and new populations are the next best tactic. Many non-native species experience a time-lag between introduction and rapid expansion (Hobbs and Humphries 1995; Binggeli 2001). An understanding of lag time is relevant to early detection of new invasions and for planning management strategies primarily because it underscores the need to closely monitor potential invaders that have not yet become problematic.

In 1996, the first NPS plan for managing non-native invasive plants (A Strategic Plan for Managing Invasive Non-native Plants on National Park System Lands) was introduced. Six key strategies were identified that included both preventing invasions and conducting inventory and monitoring of non-native plants. A revision of the NPS Invasive Species Action Plan was adopted in 2006 and included recommendations specific to an early detection monitoring program, such as:

- Rank invasive species for each park unit with significant invasive species concerns.
- Implement a system for reporting and rapidly communicating new occurrences of high priority or other invasive species.
- Identify mechanisms to work on land adjacent to parks in discretionary, cooperative efforts.

Monitoring Objectives to be addressed by the Protocol

1. Develop and maintain a list of priority invasive plant species with greatest potential for spread and impact to park resources for monitoring in each Network park, with revisions every five years.
2. Detect incipient populations and new occurrences of selected invasive plants as efficiently and effectively as possible by sampling along roads and trails and in other select locations of likely introduction before they become established. Provide the information to park management on a timely basis to allow effective management responses.
3. Use monitoring data collected early in the program to refine models of invasive species habitat requirements and of the most susceptible habitats. Adapt spatial sampling as knowledge of these high priority areas improves through monitoring.

Basic Approach

Development of the Network protocol will follow appropriate recommendations in the Invasive Species Early Detection Handbook and protocol template. A national database that will include modules for early detection monitoring is currently in development and will be adopted for use in data management and reporting.

Appendix I: Protocol Development Summaries (continued).

As of early 2007, the Klamath Network has conducted preliminary research about species in the parks (Sarr et al. 2004, Edwards et al. 2007), compiled information about likely invaders, and determined park-specific objectives. Species prioritization was conducted on a park by park basis for species that already occur in parks and additional species not yet in parks, but known to be potential invaders based on existing lists for Oregon, California, and more local weed management areas, as well as expert opinion. A procedure for how the Network will research new invasive species threats to add to the list for future re-prioritizations will be described in an SOP.

The Network's park-level prioritization process has been developed by Robert Klinger and Matt Brooks of USGS. Species prioritization has been conducted differently among Klamath Network parks according to the information currently available. The draft prioritization has been completed with existing quantitative data for Lava Beds and Whiskeytown, where there is the most information available to complement the inventory data described above. For other parks, a combination of expert opinion and other sources of information was used. Fortunately, invasive species problems are well-known among Redwood staff. In Crater Lake, all infestations have been mapped. For each park, a list of invasive species in the park, with additional species that could invade based on the literature has been was prepared. Then the prioritization of species in the colonization, establishment, and spread phases was done. Colonization phase species are the primary focus of this protocol. The other prioritizations may influence some of the sampling design under the vegetation monitoring protocol.

Monitoring of prioritized species will occur along road, trail, and powerline corridors and select campgrounds. The road, trail and powerline network will be broken into 3-5 km target segments and a random sample of segments will be surveyed every two years, except at Lava Beds, which has its own invasive monitoring program.

One end of a section of road, trail, or powerline corridor, or a campground entrance will serve as a starting point. Field crews will traverse the selected section of road, trail, or powerline corridor, or campground feature. A GPS record of the estimated infestation size of all prioritized species visible from the feature will be recorded. Absence will be determined as the inverse of presence. If non-native populations can be eradicated quickly, crews will eradicate them.

Crews will also map major habitat transitions (e.g., forest to grassland) as they traverse roads and trails. They will also place up to six 100 m^2 plots systematically within each 500 m section of road, trail, or powerline corridor to sample the presence and abundance of invasive species and selected environmental variables (percent cover, soil disturbance, elevation, habitat type, etc.). This systematic sample will be supplemented by opportunistic samples of invasive species that are detected along the trail segment. Field testing in 2008 will determine the maximum number of plots to be located per 500 m.

For the dune area at Redwood, the entire complex will be traversed so that all invasive iceplant (*Carpobrotus edulis*) can be detected and mapped and potentially controlled.

Appendix I: Protocol Development Summaries (continued).

Field methods should allow many of the roads, and trail segments at Crater Lake, Lassen, Whiskeytown, and Redwood within 5 km of a road, to be surveyed during each revisit. This will vary among parks. Some road and trail segments may be selected as survey sites to be monitored on each revisit because of their particular importance as hot spots of invasive species. This will be determined in consultation with park resource managers.

Principal Investigators and NPS Lead

Susan O'Neil, Natural Resource Specialist, helped in many aspects of protocol development. Dennis Odion and Daniel Sarr of the Klamath Network are writing the protocol with input from Rob Klinger and Matt Brooks of USGS. NPS contacts are Dennis Odion (dennisodion@charter.net, (541) 552-9624) and Daniel Sarr (dan_sarr@nps.gov, (541) 552-8575).

Development Schedule, Budget, and Expected Interim Products

The draft protocol will be completed by fall 2007, following analysis of pilot data collected in summer 2007. Following review, the protocol will be revised, and implemented if approved, in FY 2009. The budget for protocol development is $69,000. If the Non-native Invasive Plant Protocol is implemented as proposed, it will have an alternating budget appropriation of $75,000 per year of field sampling (odd years) and $10-15,000 per year for reconnaissance, data analysis, and reporting (even years).

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Appendix I: Protocol Development Summaries (continued).

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Appendix I: Protocol Development Summaries (continued).

2. Whitebark Pine

Protocol
Whitebark Pine (*Pinus albicaulis*) Vegetation Monitoring Protocol for the Klamath Network (short name: Whitebark Pine).

Parks Where Protocol will be Implemented
Crater Lake and Lassen Volcanic.

Justification/Issues being Addressed
The development of the Klamath Network vital signs monitoring has emphasized the importance of documenting status and trends in the structure, function, and composition of vegetation. It also identified keystone species as very important to monitor. Keystone species in general, and whitebark pine in particular, were ranked in the top ten vital signs for monitoring by the Klamath Network. In addition, the Network's vegetation sampling objectives identified sensitive high elevation communities for focused sampling.

Park populations of whitebark pine (*Pinus albicaulis*), a keystone species in subalpine zones of the Network, are being heavily impacted by a non-native disease. White pine blister rust, a fungal blister rust caused by the pathogen *Cronartium ribicola* (J. C. Fisch.) that affects five-needle white pines, is killing significant numbers of whitebark pine.

Monitoring of the non-native invasive pathogen and its impacts on whitebark pine is consistent with our monitoring priorities. Changes resulting from the disease are likely to have profound, ecosystem-wide effects on our subalpine zones. Whitebark pine is the dominant timberline tree in subalpine habitats at Crater Lake and Lassen Volcanic. This picturesque, long-lived, and hardy tree thrives at sites with harsh climates, where few or no other trees survive. The pine's large and nutritious seeds are prized by wildlife including Clark's Nutcrackers, black bears, golden-mantled ground squirrels, and in the past, grizzly bears (Tomback et al 2001). Elk, blue grouse, bats, and other wildlife use trees for shelter. Whitebark pine canopies support arboreal lichens, understory flora such as woodrush and currants, and possibly facilitate other plant species as well. They also stabilize soil and regulate snowmelt. Every year, nearly 500,000 people view southern Oregon's Crater Lake from its pine-clad rim where the picturesque trees are the subject of postcards and artwork. Similarly, whitebark pine is emblematic of the picturesque high elevation zones of Lassen, which are also a major visitor destination in the Network. Loss of these trees undermines the health of park ecosystems and the NPS overriding goals of maintaining natural conditions for future generations and providing a high quality natural history experience for visitors.

Some of the specific monitoring questions that will be addressed by this protocol include:

- What are infection and death rates of whitebark pine from blister rust disease, mountain pine beetle, and other agents?
- What changes in associated vegetation are due to potential factors such as climate change, succession, and natural disturbance?

Appendix I: Protocol Development Summaries (continued).

- How do management activities (prescribed fire, fire suppression, outplantings of diseased stock, managing West Nile Virus in Clark's Nutcracker, etc.) affect whitebark pine plant communities?
- Climate change/altered disturbance regimes: is there a correlation between climate change and the changes in whitebark pine ecosystems?

Monitoring Objectives to Be Addressed by Protocol

1. Determine status and trends in infection and death rates of whitebark pine from blister rust disease, mountain pine beetle, and other agents (fire, native diseases) over time.
2. Determine changes in associated plant species composition and cover associated with mortality of whitebark pine by collecting data compatible with other vegetation monitoring data.

Basic Approach

Because monitoring vegetation change associated with death of whitebark pines due to blister rust and other causes is an important objective for the Network, whitebark pine and vegetation monitoring will be co-located. In the development of the Vegetation Monitoring Protocol, after consultation with park ecologists, elevations above 2,057 m (6,750 ft) at Crater Lake and 2,424 m (8,000 ft) at Lassen were chosen as sensitive high elevation habitats in which focused vegetation monitoring will occur. Since numerous plots will be located above these elevations (see Vegetation Monitoring Protocol), it is possible an adequate sample of these probabilistically located plots containing whitebark pine will be included in the vegetation monitoring to also satisfy whitebark pine objectives. If not, it will be necessary to select additional plots probabilistically from whitebark pine stands delineated on air photos or park vegetation maps. A new vegetation map of Lassen is currently in production, while vegetation mapping at Crater Lake is slated to commence in 2009. The full vegetation sampling protocol would be employed in any plots added beyond those identified in the vegetation monitoring protocol.

Whitebark pine monitoring plots will be resampled every three years, consistent with the vegetation protocol. National-level field protocols already exist for the monitoring of white pine blister rust incidence and its effects on whitebark pines. These protocols have been developed by the Whitebark Pine Foundation with considerable input from the National Park Service, who designed the database. The Klamath Network's field protocol will incorporate this protocol, which is also being used by the Yellowstone Network. Therefore, the Klamath Network's whitebark pine protocol development will not require field research to test the efficacy of disease monitoring field methods.

The Whitebark Pine Foundation and Yellowstone Network employ a 10x 50 m transect for sampling disease symptoms. The Network's vegetation monitoring protocol was developed with this in mind. It will use a 20 x 50 plot composed of ten 10 x 10 m subplots. Monitoring of whitebark pine disease incidence may therefore occur in half of the main plot (chosen at random) and five of the subplots in their entirety. Thus, localized changes best captured at the subplot level can be directly assessed.

Appendix I: Protocol Development Summaries (continued).

Principal Investigators and NPS Lead

Through a cooperative agreement, vegetation ecologist Dennis Odion (dennisodion@charter.net; (541) 552-9624) of Southern Oregon University is completing protocol development in collaboration with Michael Murray of Crater Lake National Park, Jon Arnold of Lassen Volcanic National Park, and Daniel Sarr of the Klamath Network. The Klamath Network is also providing GIS analyses.

Development Schedule, Budget, and Expected Interim Products

The Network will produce a draft protocol by June 2008 for external peer review. After peer review, revisions, and approval, we hope to begin protocol implementation in summer 2009, beginning with plot location. We expect that adapting a protocol for the Klamath Network parks can be done for under $10,000 through utilization of existing protocols and shared time from park and network staff. Upon implementation, the annual budget for whitebark pine monitoring is expected to range between $48,000 and $52,000 during sampling years (odd years) and $10,000 and $12,000 during nonsampling years (even years).

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Appendix I: Protocol Development Summaries (continued).

3. Terrestrial Vegetation

Protocol
Monitoring Vegetation Composition, Structure, Biomass, and Combustion Properties in the Klamath Network (short name: Vegetation).

Parks Where Protocol will be Implemented
All: Crater Lake, Lassen, Lava Beds, Redwood, Oregon Caves, and Whiskeytown.

Justification/Issues being Addressed
The development of the Klamath Network vital signs monitoring has emphasized the importance of documenting status and trends in the structure, function, and composition of ecosystems. Vegetation largely defines terrestrial ecosystem structure, function, and composition in the Klamath region; it dominates biomass and energy pathways; and defines the habitat structure for many other forms of life. Vegetation ranked among the highest potential vital signs for monitoring in the Network's vital signs selection process. Vegetation is composed of primary producers upon which terrestrial and much aquatic biodiversity depends. Changes in vegetation structure, function, and composition will therefore have a profound effect on *overall* ecosystem structure, function, and composition and will be inextricably linked to the health of ecosystems. Therefore, monitoring vegetation change is imperative to detecting and understanding status and trends in park ecosystems. Vegetation is also an important part of the aesthetic and recreation experiences of park visitors and they are likely to desire information about noticeable changes in vegetation communities (e.g., redwood stands, subalpine woodlands, meadows).

Monitoring Objectives to be Addressed by Protocol
1. Determine status and trends in vascular plant composition, diversity, and structure of predominant terrestrial vegetation and select special interest vegetation (e.g., sensitive high elevation, riparian, and wetland vegetation) across the parks of the Klamath Network.
   Measurable attributes:
   - All vascular plant species present in sampling units of varying size and their cover by height strata.
   - Diameter and density of live and dead trees by species.
   - Crown position of trees.
   - Shrub density.
   - Permanent photo points and photographs of sampled area.
2. Determine status and trends in tree recruitment and in tree mortality.
   Measurable attributes:
   - Density of tree seedlings (except first year germinants) by species.
   - Levels of mortality or damage to tree crowns.
3. Determine status and trends in downed-woody fuel loadings, and in height to bottom of live crowns of standing trees.

Measurable attributes:

- Down woody debris by size and decay class for coarse woody debris.
- Measurement of height to live canopy (conifers).
- Characterization of fuels.

4. Determine status and trends in major forms of disturbance on vegetation-monitoring plots. Disturbances to be measured include fire, insect outbreaks, disease, and wind throw.
   Measurable attributes:
   - Presence or absence of fire, insect outbreaks, disease, and wind throw disturbances.

Basic Approach

Generalized Random Tessellation Stratified (GRTS) will be used to randomize and maximize spatial dispersion of plots. Sampling will occur in all the parks. Due to these practical concerns, we will limit our sampling domain by excluding areas more than one km away from roads and trails. As the objectives are not to identify road and trail impacts, plots will also be located at least 100 m from a road or trail. We will also consider travel time on trails and likely exclude areas that require more than a half day of estimated travel time from trailheads. We will also exclude areas with greater than 30^{o} slope, scree and talus slopes, and lava flows for safety reasons and because significant damage to understory vegetation occurs when crews work on steep slopes. We will also take other hazards and impenetrable vegetation (e.g., chaparral at Whiskeytown) into account in determining accessible areas.

Within these constraints, three relatively distinct vegetation strata have been delineated as separate target populations: riparian, matrix, and high elevation environments. Because not all of these strata occur in each park, there are a total of 12 unique target populations in the six parks. The Network has decided to sample four of the target populations per year with minimum nominal sampling size of n = 25 and an over-sample of approximately 60%. This yields sample sizes for each target population that are sufficiently large to ensure reasonable standard errors for parameter estimates of status in a given sampling interval (Table 3.1). Additional sampling effort has been assigned to the more extensive matrix populations (n=30) and in the particularly diverse parks (Redwood, Whiskeytown; n=40).

Table 3.1. Allocation of sampling effort for each of 12 vegetation target populations within the Klamath Network. The nominal sample size for each park has been selected with regard to desired precision and the size and vegetation complexity of the park.

Environmental Stratum	KLMN Park	Nominal Sample Size, n	Total sample after 30 years, n_o
Riparian	CRLA	26	143
	LAVO	26	143
	RNSP	26	143
	WHIS	26	143
Matrix	CRLA	30	165

Appendix I: Protocol Development Summaries (continued).

Table 3.1. Allocation of sampling effort for each of 12 vegetation target populations within the Klamath Network. The nominal sample size for each park has been selected with regard to desired precision and the size and vegetation complexity of the park (continued).

Environmental Stratum	KLMN Park	Nominal Sample Size, n	Total sample after 30 years, n_o
Matrix (continued)	LABE	30	165
	LAVO	30	165
	RNSP	40	220
	WHIS	40	220
High Elevation	CRLA (≥6750′)	26	143
	LAVO (≥8000′)	26	143
	WHIS (≥5000′)	24	133

Each target population will be revisited every three years. Fifty percent of the plots will be in a permanent revisit design, while an equal number of single visit plots will be added each year. This split panel design produces a large sample size for identifying trend that would not be possible if all plots were revisited, as indicated by the number of plots that would be sampled after ten sampling cycles, or 30 years.

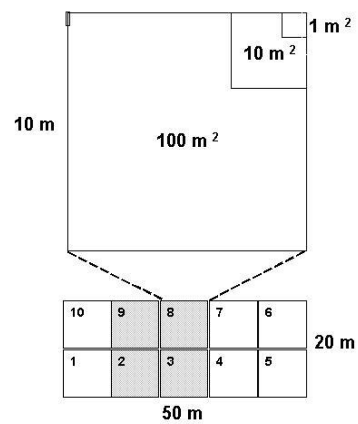

Figure 1. Vegetation plot.

Our plot design is adapted from methodologies of the Carolina Vegetation Survey (Peet et al. 1998), which have been tested and are being used in Great Smokey Mountains National Park (Jenkins 2006). According to Peet et al. (1998), this system is appropriate for diverse applications, incorporates multiple scales, yields data compatible with those from other common methods, and may be applied across a broad range of vegetation types. In the interest of reducing the time it takes for each plot, so that more plots can be sampled, the sampling intensity in Great Smokey Mountains National Park is somewhat reduced from the methods in Peet et al. (1998). We will largely follow the conventions of Great Smokey Mountains National Park. The plot is shown in Figure 1. It consists of a 20 x 50 m macroplot for tree measures and ten 10 x10 m modules, four of which (shaded) are sampled intensively for understory, tree seedlings, etc. Smaller subplots are also sampled, allowing for analyses of species area relationships at scales ranging from one m^2 to 1,000 m^2. The full set of measurements to be undertaken in the plot is described in Table 3.2.

Appendix I: Protocol Development Summaries (continued).

Table 3.2. Summary of vegetation data collected within each plot.

Component	Sampling
Species presence and cover	Ocular estimate recorded for all species in nested subplots within each of four intensive modules. Cover recorded separately for three height strata (<0.5 m; 0.5-5 m; and >5 m). Presence and cover of additional species not found in intensive modules recorded in other six 10 x 10 m modules.
Live trees ≥10 cm DBH	DBH to nearest one cm in all modules. Canopy position base height and tree condition classified.
Dead trees ≥10 cm DBH	DBH to nearest one cm in all modules.
Woody stems <10 cm DBH; ≥1.4 m height	Tallied in all modules by species into four diameter classes.
Dead woody stems <10 cm DBH; ≥1.4 m height	Tallied in all modules by species into four diameter classes.
Woody stems <1.4 m height	Density tallied by species in 3.2 x 3.2 m subplot in four intensive modules.
Herbs	Species presence tallied in 3.2 x 3.2 m subplots. Cover by species in four 10 x 10 m modules; additional species in other six modules.
Down deadwood ≥10 cm midpoint diameter	FIA/FMH approaches (planar intercept) on center transect with slightly reduced length.
Disturbance	Use checklist to tally evidence of disturbance in entire plot.

Principal Investigators and NPS Lead

Through a cooperative agreement, vegetation ecologist Dennis Odion (dennisodion@charter.net; (541) 552-9624) at Southern Oregon University is developing the protocols in collaboration with Daniel Sarr of the Klamath Network, which is also providing GIS analyses.

Development Schedule, Budget, and Expected Interim Products

A draft vegetation protocol ready for external peer review will be produced by March 2008. The Vegetation Protocol is being prepared by Dennis Odion of Southern Oregon University with assistance from Klamath Network staff. After peer review, revision, and approval, we hope to implement the protocol in spring 2009. The annual budget for vegetation monitoring is expected to range from $100,000-$115,000 annually.

Literature Cited

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Appendix I: Protocol Development Summaries (continued).

4. Bird Communities

Protocol
Landbird Monitoring Protocol for the Klamath Network (short name: Landbirds).

Parks Where Protocol will be Implemented
All: Crater Lake, Lassen, Lava Beds, Redwood, Oregon Caves, and Whiskeytown.

Justification/Issues being Addressed
Bird communities were identified within the top ten vital signs for the Klamath Network. Key reasons for monitoring landbirds in Network parks are that (1) landbirds come under the legal mandate related to the Endangered Species Act and Migratory Bird Treaty Act; (2) they are specifically identified in the management objectives of the parks; (3) they are considered good indicators of the condition of park ecosystems because they respond quickly to changes in resource conditions; and (4) comparable regional and national datasets exist and there is a long history of monitoring landbirds within the Network and on adjacent lands in the Klamath region.

Monitoring Objectives to be Addressed by Protocol
1. Determine status and trends in breeding-bird species richness and density in Klamath Network parks.
2. Determine status and trends in habitat characteristics through habitat surveys at locations where bird observations are recorded.
3. Determine status and trends in demographic information (productivity, adult survival, recruitment) of selected landbird species in mixed-conifer and riparian habitats at Oregon Caves.

Basic Approach
The Klamath Network has allocated resources to survey the presence and absence of individual species and will monitor the relative abundance of key focal species. The target populations are ensembles of bird species at five of the six parks (Oregon Caves is the exception) in the matrix vegetation environments as defined by the vegetation vital sign above. Current resources allow for approximately 60 field days per sampling season. Therefore only two or three parks within the Network will be visited in a given season to maintain sufficient sample sizes for estimating status with a reasonable level of precision. Therefore a two year revisit design will be employed.

Sampling will involve variable radius point count surveys along permanent routes, mist-netting and banding, area searches, and corresponding vegetation sampling (reléve surveys). Surveys will be done along transects that consist of 9 to 12 points separated by approximately 250 m. The entire transect is defined to be the sampling unit. The GRTS survey design used for the vegetation protocol will be employed to establish the *starting* locations of each transect. These locations are constrained by accessibility and slope, as described in the vegetation protocol development summary. A subset of the vegetation plot locations will be randomly selected. Since sampling is limited to between sunrise and about 10 a.m., it is anticipated that only a single transect can be sampled per day. The transect start locations will be restricted to the Matrix that are easily accessed (i.e., within *m* meters of an established road or trail), thereby reducing the actual target population(s).

Sampling will consist of variable radius point count surveys. Regional- and national-level protocols already exist for these bird monitoring techniques and vegetation surveys that will be implemented. Therefore, protocol development will not require field research and will consist primarily of adapting these methods to NPS standards and incorporating existing standard protocols.

Principal Investigators and NPS Lead

Protocol development will be done through a cooperative agreement with the Klamath Bird Observatory (www.klamathbird.org; (541) 201-0866). Principal Investigators will be Jaime Stephens and John Alexander. The NPS Lead is Sean Mohren, Klamath Network (sean_mohren@nps.gov; (541) 552-8576).

Development Schedule, Budget, and Expected Interim Products

The Principal Investigators will a draft protocol ready for external peer review by September 1, 2007. The total budget for protocol development is $15,000. The budget for bird community monitoring is expected to range from $20,000 in odd years to $80,000 in even years in an alternating intensity sampling program.

Appendix I: Protocol Development Summaries (continued).

5. Intertidal Communities

Protocol
Intertidal Marine Resources of Redwood National Park (short name: Intertidal).

Parks Where Protocol will be Implemented
Redwood.

Justification/Issues being Addressed:
Intertidal communities consistently ranked among the top ten potential vital signs evaluated by Klamath Network in its scoping process (note: the specific rank depended on the weighting of management and ecological significance and monitoring costs and feasibility). The Network specifically identified terrestrial, freshwater aquatic, subterranean, and marine ecosystems as critical to comprehensive vital signs monitoring. Intertidal communities and kelp forests were the two marine community types with highest ecological significance, but the latter scored lower in terms of cost and feasibility. Thus, the only marine resources that we propose to monitor are intertidal communities.

Key reasons for monitoring intertidal communities are their unique species composition and diversity and their position at the land/sea interface, which result in particular sensitivity to ongoing changes in both marine and terrestrial realms (e.g., climate change and associated changes in sea temperatures, circulation patterns, and surface elevation). Intertidal communities are also highly vulnerable to anthropogenic stressors such as oil spills. Finally, the Klamath Network has put a premium on monitoring of keystone species. A classic example of a keystone species occurring in west coast intertidal systems is the sea star *(Pisaster ochraceou*s) (Paine 1969).

Monitoring Objectives to be Addressed by Protocol
1. Monitor the temporal dynamics of target invertebrate and algae species (listed in protocol) and surfgrasses across accessible, representative, and historically sampled sites at Redwood National and State Parks that encompass the range of rocky intertidal habitats in the parks to: (1) evaluate potential impacts of visitor use or other park-specific activities, and (2) provide monitoring information to help assess level of impacts and changes outside normal limits of variation due to oil spills, non-point source pollution, or other anthropogenic stressors that may come from outside the parks.
2. Determine status, trends, and effect sizes (as applies) through time for morphology (e.g., color ratios) and other key parameters describing population status (e.g., size structure) of the selected intertidal organisms.
3. Integrate data with a network of monitoring groups spanning a broad geographic region in order to determine whether trends detected at Redwood are related to more widespread trends or are park-specific.
4. Detect and document invasions, changes in species ranges, disease spread, and rates and scales of processes affecting the structure and function of rocky intertidal populations and communities to develop process knowledge of processes and normal

limits of variation. Assess the temporal dynamics of target species across multiple sites and integrate data with a network of monitoring groups spanning a broad geographic region.

Basic Approach

The sampling design will follow the established protocols of the MARINe (Multi-Agency Rocky Intertidal Network) program, which trace their development in large part to monitoring protocols established at Channel Islands National Park. Methods involve biannual sampling of permanent photoquadrats, seastar (*Pisaster ochraceou*s) plots, and surfgrass *(Phyllospadix* spp.) transects. Monitoring would continue in conjunction with an existing intertidal monitoring network (MARINe). This network samples sites from northern Oregon to southern California with the Redwood National and State Parks intertidal monitoring sites filling in a geographic gap in northern California.

Monitoring of the rocky intertidal marine resources at Redwood, according the MARINe protocol, was initiated in 2004 at Damnation Creek, False Klamath Cove, and Enderts Beach Cove. Our Intertidal Protocol proposes to make this monitoring permanent.

The MARINe protocols are codified and described in detail in the following:

Engle, J. M. 2005. Unified monitoring protocols for the multi-agency rocky intertidal network. US Minerals Management Service.

Therefore, this document will be incorporated in its entirety into the Klamath Network protocol as an SOP. It is subject to periodic revision as more becomes known about trends and stressors in intertidal systems. Thus, the protocol will specify that the SOP is to be revised directly upon each revision of the MARINe protocol.

There is also a detailed MARINe database user guide that provides instructions for all data entry and a description of all files in the database and the fields they contain (i.e., a "data dictionary") in the following:

Bealer, B., and L. Cooper. 2003. MARINe database user guide. Version 3.1. Southern California Coastal Water Research Project, Westminster, CA.

This user guide will be incorporated by reference in the data management SOP, but will not be included in our protocol in order to keep this document from excessive size.

There are three additional, detailed documents supporting the Network's Intertidal Protocol: a sample report (Cox and McGary 2006), a power analysis of existing MARINe data (Minchinton and Raimondi 2005), and the original intertidal protocol from Channel Islands National Park (Richards and Davis 1988). All documents upon which our Intertidal Protocol rests, including all versions of the protocol itself that come to exist, as well as the full MARINe protocol and database user guide, will be housed in a digital library with the Klamath Network and will be available through the Network website.

Appendix I: Protocol Development Summaries (continued).

An affiliation between the Network and existing regional/national-level protocols and data for an intertidal monitoring program greatly strengthens our ability to meet the objectives. Furthermore, because we may incorporate these existing standard protocols into the Network's, the protocol's development will require limited field research and will consist primarily of writing to NPS standards. The protocol narrative and SOPs will make the standard protocols specific to the existing sampling at Redwood. These will detail sampling locations and how data, analyses, and reports will be transferred to NPS computers, further analyzed and summarized, and reported to the Network's audience.

Principal Investigators and NPS Lead

Ongoing monitoring and development of the long-term monitoring protocol is being done through a cooperative agreement with the Center for Ocean Health/Long Marine Lab, University of California, Santa Cruz. The Principal Investigator is Peter Raimondi with research assistant Karah Cox. The NPS lead at Redwood is David Anderson (david_g_anderson@nps.gov; (707) 465-7771). The Klamath Network contact is Dennis Odion (dennisodion@charter.net; (541) 552-9624).

Development Schedule, Budget, and Expected Interim Products

The Principal Investigators produced a draft Intertidal Protocol ready for external peer review on March 1, 2007. After peer review, revision, and approval, we hope to continue the monitoring uninterrupted. We have budgeted $75,000 to adapt and field test the protocol in FY 2006-2007, and $30,000 a year as a scheduled annual appropriation to fund the long-term monitoring thereafter.

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Cox, K., and C. McGary. 2006. Marine resources of Redwood National and State Parks: Comprehensive report (2004-2005) for Humboldt and Del Norte County, California. NPS Report REDW-00008. Unpublished report on file. U.S. Department of the Interior, National Park Service, Klamath Inventory and Monitoring Network, Ashland, OR.

Minchinton, T. E., and P. T. Raimondi. Effect of temporal and spatial separation of samples on estimation of impacts. MMS OCS Study 2005-002. MMS Cooperative Agreement Number 14-35-0001-30758. Coastal Research Center, Marine Science Institute, University of California, Santa Barbara, CA.

Paine, R. T. 1969. A note on trophic complexity and community stability. The American Naturalist **103**:91-93.

Richards, D. V., and G. E. Davis. 1988. Rocky intertidal communities monitoring handbook, Channel Islands National Park, California. National Park Service, Ventura, CA.

Appendix I: Protocol Development Summaries (continued).

6. Water Quality and Aquatic Communities

Protocol
Monitoring Water Quality and Aquatic Communities in the Klamath Network Parks.

Parks Where Protocol will be Implemented
Crater Lake, Lassen Volcanic, Oregon Caves, Redwood, and Whiskeytown.

Justification/Issues Addressed
During the Klamath Network vital signs scoping process, water quality of the Network's aquatic resources was identified as an important element of the overall health of the Network's diverse ecosystems. Two of the 10 most important Network-wide vital signs identified by this process were (1) water quality characteristics of surface waters, and (2) aquatic biota and communities. The monitoring questions associated with these vital signs were, respectively: (1) what are the status and trends of surface waters and pollutants, and (2) what are the status and trends in the structure and composition of locally limited (i.e., focal) aquatic communities?

Aquatic ecosystem health has consistently been the dominant theme during the identification of Network-wide water quality issues. The ability to (1) document improvement (or lack thereof) in the water quality of Clean Water Act section 303(d) listed impaired streams, and (2) the ability of park managers to document progress toward achieving GPRA goal 1.a4 (i.e., that parks have unimpaired water quality) has underscored the importance of identifying a suite of measurement parameters useful for effective water quality assessment. The need to fully inventory aquatic resources and document baseline and reference water quality conditions also were identified as important objectives in the development of a vital signs-based long-term water quality monitoring program.

Monitoring Objectives to be Addressed by Protocol
The fundamental goal of this integrated protocol is to provide guidance for monitoring the status and trends of the water quality and aquatic communities of Klamath Network perennial, surficial freshwater ecosystems, specifically: (1) perennial, montane ponds and lakes (CRLA, LAVO), (2) perennial, montane wadeable cold-streams (CRLA, LAVO, WHIS), (3) perennial, coastal and Coast Range wadeable cold-streams (REDW), and (4) cave-associated wadeable cold-streams (ORCA). Measurable objectives of the plan include:

1. Sample a suite of physical, chemical, and biological parameters that can be used to determine site-specific and ecosystem-level baseline water quality and aquatic community conditions of the freshwater systems being monitored.
2. Develop and maintain a database and associated metadata for storing data derived from the measurement and analysis of physical, chemical, and biological parameters sampled for each monitored ecosystem.

Appendix I: Protocol Development Summaries (continued).

3. Analyze data using a suite of statistical tools useful for documenting the status and trends of the ecosystems being monitored; based on this analysis, identify for each ecosystem any possible site-specific and ecosystem-level deviance beyond natural variation in baseline conditions.
4. Report the results of status and trend analyses annually and provide ongoing synthesis of annual reports no more than one year after the completion of each 3-year monitoring cycle.

Basic Approach

A split-panel, revisit design (Urquhart et al. 1998; McDonald 2003) will be used to sample perennial, surficial freshwater ecosystems. The panels consist of randomly selected index sites that will be visited and sampled every third year; and randomly selected survey sites that will be visited and sampled once every 30 years (see Table 6.1 for LAVO example). A limited number of subjectively selected judgment sites also will be visited and sampled once every third year. Judgment sites will be selected based on a perceived and justifiable need to include them as part of the monitoring program. They will allow managers to sample sites of particular interest that: (1) have been historically sampled and would benefit from continued sampling, (2) have attributes and/or characteristics of ecological interest, (3) have some impact (e.g., visitor-attributed disturbance) or perturbation (e.g., contamination due to atmospheric deposition of nutrients or tailings from past mining activities) that requires long-term monitoring, and/or (4) need to be sampled due to a statutory directive or requirement (e.g., Clean Water Act section 303[d] sites).

Table 6.1. Yearly and total sample sizes over ten sampling years for index and survey sites in a split-panel, revisit design for aquatic communities and water quality monitoring at Lassen Volcanic National Park. The index sites will be visited every third year [1-2], with the survey sites visited once every 30 years [1-29] (from Klamath Network Vital Signs Monitoring Plan, Table 4.1).

		Sample Occasion										
Panel		***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	**Total Sample Size**
1	*Index Sites* [1-2]	12	12	12	12	12	12	12	12	12	12	**12**
2	*Survey Sites* [1-29]	14										
3			14									
4				14								
5					14							
6						14						
7							14					
8								14				
9									14			
10										14		
11											14	**140**
Yearly Sample Size		26	26	26	26	26	26	26	26	26	26	**152**

Appendix I: Protocol Development Summaries (continued).

The sampling design will utilize a 3-year rotation in which parks and ecosystems will not be visited and sampled in the same years (see Table 6.2). In the first year, only streams will be sampled at REDW, CRLA, and ORCA; in year 2, only streams will be sampled at WHIS, LAVO, and ORCA; and in year 3, only ponds and lakes at CRLA and LAVO, and one freshwater lagoon at REDW will be sampled. This design will accommodate the sampling of similar ecosystems in the same year(s) and allow a greater number of sites to be sampled per ecosystem type in each park. We also have grouped relatively low elevation parks (e.g., REDW and WHIS) with relatively higher elevation parks (e.g., CRLA and LAVO) in the first two years of sampling so that lower elevation sites will be available for sampling early in the summer field season when higher elevation sites may not be accessible. In many years this will allow the summer field season to begin in mid-June instead of mid- to late July if only higher elevation locations were to be sampled. However, since only montane ponds and lakes will be sampled in year 3, all but one sampling site (i.e., REDW freshwater coastal lagoon) will be located in higher elevation parks during that sampling year.

Table 6.2. Number of sites to be sampled during the first three years of monitoring in Klamath Network parks. For wadeable cold-streams: numbers in parentheses equal number of streams; numbers not in parentheses equal number of 100-m sampling sites.

Year	Ecosystem	Park	Judgment (J)	Index (I)	Survey (S)	Total (I&S)	All Sampling Sites (J + I&S)
1	Wadeable cold-streams	REDW	(2) 4	(6) 12	(7) 14	(13) 26	(15) 30
		ORCA	(1) 3	—	—	—	(1) 3
		CRLA*	(2) 4	(6) 12	(7) 14	(13) 26	(15) 30
2	Wadeable cold-streams	WHIS	(1) 3	(4) 12	(5) 15	(9) 27	(10) 30
		ORCA	(1) 3	—	—	—	(1) 3
		LAVO	(1) 2	(6) 12	(7) 14	(13) 26	(14) 28
3	Ponds and Lakes	REDW	1	—	—	—	1
		LAVO	1	14	14	28	29
		CRLA	—	14	14	28	28

* includes two wadeable cold-stream sampling sites and two fen sampling sites

Perennial, Wadeable Cold-Streams: The sampling frame for streams will be a list of all named perennial cold-streams derived from a GIS layer that includes all cold-streams in each park, except at ORCA where only one stream will be considered for monitoring. There will be five sampling frames: (1) REDW streams, (2) WHIS streams, (3) CRLA streams, (4) LAVO streams, and (5) the ORCA stream associated with a cave-complex. The target population for each sampling frame will be composed of two or three 100-m sampling sites located within each selected stream. Note that streams will be selected separately for each park. The number of sampling sites per stream will vary by park (i.e., CRLA, LAVO, and REDW = two sampling sites/stream; WHIS and ORCA = three sampling sites/stream). Stream and sampling site selection will proceed as follows: (1) subjectively selected judgment streams will be identified and removed from the list of named streams, (2) Index streams will be randomly selected and removed from the list of the remaining named streams, (3) Survey streams will be randomly selected from the named streams remaining on the list after Index stream selection, (4) GRTS will be used to randomly select two or three 100-m sampling sites/stream for index and survey streams, and (5) Judgment stream sampling sites will either be non-randomly appointed or randomly selected. The criteria for stream and sampling site selection include: (1) streams will be <1000 m from an active road or trail, (2) sampling sites will be 100-m sections of stream length <1000 m from an active road or trail, (3) sampling sites will be located on slopes <30 degrees.

During the year in which streams in a park are scheduled to be visited, for example REDW in Year 1 (Table 6.2), a suite of physical, chemical, and biological parameters will be measured at all sampling sites. In off years, for example REDW streams in Years 2 and 3, only a limited number of core parameters (e.g., water temperature, specific conductance, dissolved oxygen, pH, flow/discharge, turbidity, and macroinvertebrates) will be measured and/or sampled at sites in judgment and index streams. Core parameters will not be measured in off years at sites in survey streams. A total of 119, 100-m sampling sites (Table 6.2) will be sampled during Years 1 and 2 of the first three-year monitoring period, including 14 judgment sites (12%), 48 index sites (40%), and 57 survey sites (48%).

Montane Ponds and Lakes: The sampling frames for ponds and lakes will be: (1) CRLA GIS layer of perennial ponds and lakes outside of the Crater Lake caldera, (2) LAVO GIS layer of perennial ponds and lakes, and (3) one freshwater lagoon at REDW. The target population, except for the freshwater lagoon, will be individual ponds and lakes (hereafter called sampling sites) that are <25 m maximum depth, <1000 m from an active road or trail, and located in an area where slopes are <30 degrees. Like wadeable cold-streams, pond-lake judgment sampling sites will be subjectively selected and removed from the list of suitable sites. Index sampling sites will then be randomly selected and removed from the list followed by the random selection of survey sampling sites.

During the year in which ponds-lakes are to be sampled (i.e., year 3; Table 6.2), a suite of physical, chemical, and biological parameters will be measured at all sampling sites. In off years (i.e., years 1 and 2; Table 6.2), only a limited number of core parameters (e.g., water temperature, specific conductance, dissolved oxygen, pH, water-level, and macroinvertebrates) will be measured and/or sampled at judgment and index sampling sites. Core parameters will not be measured in off years at survey sampling sites. A total of 58 ponds, lakes, and a freshwater lagoon will be sampled in year 3 of the first three-year monitoring period, including two judgment sites (4%), 28 index sites (48%), and 28 survey sites (48%).

Parameters to be Monitored: Temperature, specific conductance, dissolved oxygen, and pH (core parameters) will be measured at each site. In addition, water-level will be measured at pond-lake sites and flow/discharge will be assessed at wadeable cold-stream sites.

Appendix I: Protocol Development Summaries (continued).

Physical habitat characteristics to be measured at pond-lake sites include elevation, surface area, perimeter, maximum depth, water clarity, inlet and outlet assessment, basin characteristics (e.g., aspect, geology, and origin), vegetation zone, and bathymetry. Physical habitat characteristics to be measured at wadeable cold-stream sites include elevation, thalweg profile, channel and riparian characteristics, turbidity, woody debris tally, channel constraint, and assessment of debris torrents and major floods.

Water chemistry parameters to be measured at all sites include alkalinity, cations and anions, total nitrogen, ammonia, nitrate/nitrite, total phosphorus, silica, total suspended solids, and dissolved organic carbon. Biological community parameters to be measured at all sites include benthic macroinvertebrates, amphibians, and fish. In addition, samples for chlorophyll and zooplankton analysis will be collected at pond-lake sites and periphyton samples will be collected at wadeable cold-stream sites. Samples for determining the presence/concentration of fecal indicator bacteria also will be collected at wadeable cold stream sites in ORCA and WHIS.

There are two Clean Water Act section 303(d) listed impaired sites that will be monitored as part of the monitoring plan: (1) Redwood Creek (REDW) which is listed on the CWA 2002 and 2006 lists for impaired waters in California, and (2) Willow Creek (WHIS) which was previously but is not presently listed on the CWA 2006 list for impaired waters in California. Redwood Creek will be monitored for temperature and sedimentation/siltation and Willow Creek will be monitored for heavy metals.

The following protocols will be used and/or revised for the development of the Klamath Network water quality and aquatic communities protocol:

1. Environmental Monitoring and Assessment Program - Surface Waters: Western Pilot Study Field Operations Manual for Wadeable Streams. EPA, unpublished draft (Peck et al. 2001).
2. Freshwater Quality Monitoring Protocol Version 2.01 – San Francisco Bay Area Network (Cooprider 2005).
3. Sampling Protocol for Monitoring Abiotic and Biotic Characteristics of Mountain Ponds and Lakes, 2005, US Geological Survey Techniques and Methods 2-A2 (Hoffman et al. 2005).
4. Random X Survey Techniques – 2003 Update (Bury et al. 2003).
5. Protocol for Determining Bull Trout Presence (Peterson et al. 2002).
6. Ground-based Photographic Monitoring (Hall 2001).

The Klamath Network protocol will include 14 SOPs:

1. SOP 1: Revising the Protocol: to be adapted from SOP 1 of the SFAN Freshwater Quality Monitoring Protocol.
2. SOP 2: Personnel Training and Safety: to be adapted from SFAN SOP 2.
3. SOP 3: Equipment and Field Preparation**:** to be adapted from SFAN SOP 3.

Appendix I: Protocol Development Summaries (continued).

4. SOP 4: Quality Assurance Project Plan (QAPP): this SOP will be developed following NPS guidance (Irwin 2004).
5. SOP 5: Field Methods for the Measurement of Core Parameters: to be adapted from the following protocol SOPs: wadeable cold-streams: SFAN SOP 5 and 9; ponds-lakes: USGS-NCCN SOP 2, 3, and 5. Additional guidance available from NPS-WRD (2002).
6. SOP 6: Field Methods for the Measurement of Physical Characteristics: to be adapted from EMAP Section 7 for wadeable cold-streams, and USGS-NCCN SOPs 1, 2, and 4 for ponds-lakes.
7. SOP 7: Field Methods for the Measurement of Water Quality Samples: to be adapted from SFAN SOP 7 for wadeable cold-streams, and USGS-NCCN SOP 5 for ponds-lakes.
8. SOP 8: Field Methods for the Collection of Biological Samples: to be adapted from EMAP Sections 8 and 11 for wadeable cold-streams, and USGS-NCCN SOPs 6, 7, and 8 for ponds-lakes.
9. SOP 9: Field Methods for the Assessment of Amphibians and Fish: to be adapted from Random X and Protocol for Determining Bull Trout Presence for wadeable cold-streams, and USGS-NCCN SOPs 9 and 12 for ponds-lakes.
10. SOP 10: Field Methods for Sampling Fecal Indicator Bacteria**:** to be adapted from SFAN SOP 6.
11. SOP 11: Field and Laboratory Methods for Sediment: to be adapted from SFAN SOP 8.
12. SOP 12: Data Analysis: to be adapted in part from SFAN SOP 10.
13. SOP 13: Data Reporting: to be adapted in part from SFAN SOP 11.
14. SOP 14: Site Selection and Documentation: the photo-documentation part of this SOP will be adapted from Hall 2001.

Some water chemistry and biological samples will be processed and analyzed by contract laboratories. Sample processing and analysis by these laboratories will meet NPS and USGS QAPP requirements. Laboratory results and field generated data will be entered into a Network database. The Klamath Network has chosen to use the NPSTORET database for all aquatic and water quality monitoring projects. Results and field-generated data will be examined as soon as possible after they are available to: (1) ensure that results are within the range of expected values; (2) identify problems with the sampling program, laboratory, or data entry; and (3) identify important occurrences or trends that might warrant a modification in the monitoring program or a management response.

A metadata file that meets NPS and USGS requirements also will be created for data generated by the Klamath Network aquatic resources monitoring program.

Principal Investigators and NPS Lead

The NPS lead for protocol development is Daniel Sarr (Network Coordinator). Principal Investigators are Jason Dunham (Research Aquatic Ecologist, USGS Forest and Rangeland Ecosystem Science Center) and Robert Hoffman (Ecologist, USGS Forest and Rangeland Ecosystem Science Center).

Appendix I: Protocol Development Summaries (continued).

Development Schedule, Budget and Expected Interim Products

A draft protocol for monitoring water quality and aquatic communities in Network ponds-lakes and wadeable cold-streams will be prepared. Pilot testing of the protocol by summer 2008 will evaluate sample site selection and location, sample processing in the field, and the logistics of accessing sites and transporting/delivering samples. The Klamath Network has budgeted approximately $110,000 in fiscal year 2008 for the aquatic resources monitoring program.

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Appendix I: Protocol Development Summaries (continued).

7. Cave Entrance Communities and Cave Environment

Protocol
Integrated Cave Entrance Community and Cave Environment Monitoring for the Klamath Network.

Parks Where Protocol will be Implemented
Oregon Caves and Lava Beds.

Justification/Issues being Addressed
Since there are only two NPS units in the Klamath Network that have significant cave resources and since cave experts were underrepresented in the Network's' vital signs ranking process, cave resources ranked fairly low among the potential vital signs evaluated by Klamath Network (note: the specific rank depended on weighting of management and ecological significance as well as cost and feasibility of monitoring). However, the Network specifically identified subterranean ecosystems as one of the four ecosystem domains (along with terrestrial, freshwater aquatic, and marine) that would define the scope of a comprehensive vital signs monitoring program. Moreover, caves and lava tubes are central to the enabling legislation of Oregon Caves and Lava Beds National Monuments. Cave entrance communities (technically not completely subterranean) scored the highest as a sensitive focal community type found in the subterranean ecosystem domain. Other subterranean potential vital signs scoring highest included various biological and geological aspects of cave environments. Ranking of cave-related monitoring questions, which was based on ecological and management significance and not sensitivity to anthropogenic stressors, is provided in Table 3 below. The questions illustrate the broad array of concerns about abiotic and biotic subterranean resources. For all these reasons, the Network identified cave entrance communities and environments as vital signs of subterranean ecosystem health.

There are a number of good reasons for monitoring caves and cave entrance communities. Foremost, these communities have unique biota, including a number of global endemics. For example, macroinvertebrate troglobites are known only from caves. There are about seven to eight macroinvertebrate species and one subspecies known only from the main cave at Oregon Caves. Lava Beds has at least three troglobitic species only known from their lava tube caves, including a troglobitic isopod (Trichoniscidae), pseudoscorpion, and dipluran. At Lava Beds, there are also ferns and both vascular and non-vascular plants that are mostly or entirely restricted to cave entrances. These cave communities can be highly vulnerable to human impacts (e.g., any locally introduced organic matter) and to cave entrance alterations. Even such seemingly minor stresses as lint from a visitor's clothing can affect microbial populations, which are the main basis of the macroinvertebrate food chain.

The distinctive biodiversity and often spectacular geologic formations in caves depend on unique and specific environmental conditions. Despite their apparent stability, cave environments often show particular sensitivity to ongoing changes in both atmospheric and terrestrial realms (e.g., climate and atmospheric composition change). These changes affect temperatures, microclimates, carbon dioxide concentrations, and the amount and type of organic input into caves. The geological processes in caves can be affected by all these changes, as well as by local effects of visitor use. Caves are truly among the most sensitive natural resources to anthropogenic impacts.

Monitoring Objectives to be Addressed by Protocol

Determine status and trends in specific features and resources in managed and unmanaged caves along a gradient from cave entrance to cave interior.

The following resources and parameters have been identified to monitor:

- Plants: measures of abundance (density, cover, frequency) at cave entrances.
- Bats: harp trap counts, timed visual counts.
- Macroinvertebrates: aggregate macroinvertebrate sample, use of attractants.
- Microbes: cave sediment biological activity.
- Air flow, relative humidity, temperature using instrumentation.
- Calcite slab for dissolution and deposition.
- Ice features.
- Impacts to cave formations.
- Lint deposition.
- Surface polishing.

Basic Approach and Organization of Protocol

The integrated protocol is under development. Meetings have been held by the Network involving its cave experts and outside experts from other NPS units around the country. Cave experts also convened at the National Speliological Society Meeting in August 2006 to discuss the Klamath Network's monitoring protocol.

Some monitoring (instrument-based) would be continuous and some would be periodic. The spatial sampling designs and revisit designs for periodic monitoring need to be developed. Representative developed and undeveloped caves will be chosen. These will be chosen subjectively at Oregon Caves but randomly at Lava Beds, using a list-based approach. Sampling will occur along a gradient from cave entrance to interior with randomization of actual sample locations. Only caves considered suitable by experts would be on the selection list for Lava Beds. A greater number of cave entrance communities than cave interiors are likely to be sampled at Lava Beds. Some vegetation and bird community sampling will likely be co-located with other cave entrance community monitoring.

Cave experts from Oregon Caves (John Roth) and Lava Beds (David Larson and Shane Fryer) are developing a document describing methods to monitor the resources described above to use in the protocol for the two parks. This document will help provide a basis for the protocol and vital information for protocol developers.

Appendix I: Protocol Development Summaries (continued).

Principal Investigators and NPS Lead

Development of the long-term monitoring protocol will be completed through a cooperative agreement funded by the National Cave and Karst Research Institute located in Carlsbad, New Mexico. The institute will work with the Klamath Network staff and staff of Oregon Caves (John Roth) and Lava Beds (David Larson).

Development Schedule, Budget, and Expected Interim Products

The Principal Investigators will produce a draft Cave Protocol ready for external peer review by June 2008. After peer review, revision, and approval, we hope to begin implementing monitoring in FY 2009. The Klamath Network is scheduled to appropriate approximately $50,000 per year for the implementation of this integrated cave protocol.

Appendix I: Protocol Development Summaries (continued).

8. Land Cover Monitoring Protocol for the Parks of the Klamath Network

Protocol
Land Cover Monitoring Protocol for the Klamath Network.

Parks Where Protocol will be Implemented
Crater Lake, Lava Beds, Lassen Volcanic, Whiskeytown, Redwood, and Oregon Caves.

Justification/Issues being Addressed
Landscape spatial structure resulting from natural processes, and its variation through time, underlies the diversity and integrity of ecosystems. The composition (types and amounts of different land-cover), configuration (spatial arrangement of land-cover types), and connectivity determine habitat availability, the movements of organisms, and energy and material flows on a landscape (Turner et al. 2001).

Substantive changes in landscape structure occur in response to natural and anthropogenic processes. The latter are of particular concern and relevance for vital signs monitoring. For example, the area on the eastside of Whiskeytown is experiencing rapid suburban and rural development. Less severe, but potentially significant development pressure also affects some areas adjacent to Redwood. In addition, Redwood, Crater Lake, Lassen, Oregon Caves, and Whiskeytown all adjoin lands managed for timber production. Existing imagery shows intensive forest cutting adjacent to Crater Lake's southeastern border has greatly altered landscape patterns and habitat connectivity. Following a 2004 fire, burned forest habitat near Whiskeytown was clearcut logged and further denuded by subsequent erosional processes. In both cases, adjacent habitat was fragmented and degraded in a way that could affect park wildlife, visual resources, etc.

In all parks, natural disturbance regimes may be changing in relation to climatic conditions. These changes are difficult to predict due to uncertainty about how climate change will affect precipitation patterns in the region. The glaciers on Mt. Shasta are growing, indicating the potential for increased precipitation. Conversely, warming temperatures could affect snowmelt or fog patterns in Redwood, even reducing effective precipitation. Monitoring current and future influence of climate change and effects on natural disturbances in landscapes is key to understanding changes in ecosystem structure, function, and composition, all considered integral to monitoring vitality of the Network park ecosystems. Also, discerning between natural and anthropogenic forces of change is critical to effective mitigation action. Management actions seldom influence natural processes, but they can be effective in mitigating human-induced changes.

Monitoring Objectives to be Addressed by the Protocol
1. Determine the status and trends in the composition and configuration of land-cover classes within all the Network parks and directly adjacent land at five-year intervals.
2. Determine the status and trends in the connectivity of the land cover classifications, also at five-year intervals.

Appendix I: Protocol Development Summaries (continued).

3. Determine the status and trends in cross-boundary (park vs. adjacent lands) contrasts in land-cover types at five-year intervals.
4. Determine long-term changes in fire frequency and extent.
5. Determine long-term changes in the frequency and extent of insect and disease outbreaks.

Basic Approach

The protocol has yet to be developed. What follows is a general outline of the expected approach based on standards from other networks. Changes will follow in accordance with experiences of networks that have already implemented land cover monitoring.

Land-cover information will be derived from Landsat or similar satellite imagery. Imagery may be acquired every five years for the full extent of all parks, and for at least a five km swath around the boundary of a park. Supervised classification will be used to generate land-cover classes for change detection.

Change-detection will be evaluated in several ways. Differences in spectral properties between sequential time periods will be used to produce a change-detection map. This approach relies on the raw digital number of spectral bands, not classification, and provides the most accurate measure of change. Where differences are detected, ground-based assessments or supporting information and observations from park staff will verify that change occurred and reasons for changes. Extent and spatial properties of change will serve as basic indicators of change and be used in status and trend assessments. Additionally, substantive changes will appear as differences in classified land-cover maps. Status and trend assessments will be performed using a parsimonious set of landscape metrics that characterize composition (extent of land-cover types), configuration (e.g., patch size distributions, dispersion, juxtaposition), and connectivity (largest patch size and related measures) of land-cover types. Composition and configuration measures will be generated for all land-cover types. Connectivity measures will be derived for specific or combined cover types. Metrics will be generated using standard software, and where necessary, customized programs. All land-cover related metrics will be generated separately for park and for adjacent lands; connectivity and Network-related measures will apply to park lands and to parks and adjacent lands combined. Cross-boundary measures will consist of edge-contrast measures. These will be assessed by Network and park staff and be based on known or perceived functional differences between cover types.

Disturbances will be monitored indirectly. Large-scale changes in land-cover types between years likely will indicate disturbance. When such changes are detected, ground-based assessments will determine the occurrence and type of disturbance. Over a long time frame, the time series of observed disturbance frequency and severity will be used to determine changes in disturbance regimes. Monitored climate information will aid in detecting and understanding reasons for changes in disturbance regimes.

Appendix I: Protocol Development Summaries (continued).

Principal Investigators and NPS Lead

Protocol development is being done by the Network GIS technician (Chris Zanger) and with Dennis Odion using a cooperative agreement with Southern Oregon University. We anticipate working with Robert Kennedy, Oregon State University, Department of Forest Science, with whom the Network has involved in its remote sensing workshop.

Development Schedule, Budget, and Expected Interim Products

The Klamath Network expects to develop a Landcover/Land use Protocol in FY 2007, with implementation scheduled to begin in FY 2008. The Network will designate approximately $20,000 every five years to conduct Landcover/Land use monitoring. We expect that land cover change will be evaluated by the Klamath Network Data Manager with some assistance from outside scientists.

Literature Cited

Turner, M. G., R. H. Gardner, and R. V. O'Neill. 2001. Landscape ecology in theory and practice. Springer-Verlag, New York, NY.